



GAMA Days 2022

International meeting of GAMA users

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GAMA days is a FREE and ONLINE International Conference where users and developers of the GAMA modeling and simulation platform have the opportunity to meet.



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A serious game to raise awareness about the impact of mobility habits

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Keywords

Mobility, ecology, cognitive biases, habits, serious game

Abstract

The impact of cars is well-known, both on global warming and on health, but their count keeps growing along with distances travelled. Public policies could have a positive impact, but aside of emergencies (lockdown for the COVID-19 epidemics), they take time to set up, and are not easily accepted (strikes against petrol price rises) in particular by citizens who depend (or believe they do) on cars. New forms of mobility also emerge, and it is necessary to debate about how the urban space can evolve and be better shared. To this end, we propose the SWITCH serious game, where the player changes perspective by taking on the role of an urban manager in charge of improving city indicators (pollution, accidents...) while maintaining accessibility and satisfaction of the simulated population.

This game is based on an agent-based simulation of commuting [2] where citizens choose among 4 mobility modes (walk, bicycle, bus, car) based on a rational evaluation of 6 criteria (ecology, price, time, comfort, safety, praticity) depending on features of the city (bus network, parking availability, trees...) that the player can modify through their actions. Citizens also develop habits over time that can override their rational choice [1]. Their satisfaction depends on their ability to move (accessibility) and on their subjective evaluation of the mobility mode they select.

This game is implemented in GAMA [3]. Each turn, the player gets a yearly budget to pay for their actions at different levels: **taxes**, changing tax rate, petrol price, public transport subscriptions; **urban planning**, building cycling lanes, carparks, planting trees, maintaining roads, improving public lighting; **public transport network**, increasing or decreasing bus frequency or coverage, changing their capacity. More actions could be added to modify regulations (pedestrianisation, restrictions for older cars...) or public communication. Each action has a financial cost but also consumes some space in the simulated town. A balance must therefore be found to share space equitably between mobilities.

The player can select as many actions as desired with the only limitation of the available budget. Actions are selected via buttons and/or by clicking on the map. They influence the simulated population, but their impact is limited by the inertia created by mobility habits and biases. The player gets immediate feedback on the impact of their actions through the interface:

- The console displays the cost of each action applied, and the remaining budget.
- One tab provides textual information about the values of all criterias for all mobility modes, as well as city indicators (pollution, traffic quality, number of accidents...)
- The map displays the city, the road network, the citizens' movements, the diffusion of pollution.
- Another tab shows pie charts for the distribution of trips over the 4 mobility modes.

The game should be played in pairs to favour interactions before selecting actions. It should be followed by a debriefing phase in order to compare actions of different players, discuss their difficulties, and measure the impact of the game on their opinions about mobility, in particular about users of other modes than their preferred one.

Additional material

Screenshot of the game and additional material can be found at:

<https://sites.google.com/site/caroleadamphd/projects/switch>

References

- [1] A. Jacquier and C. Adam. Agent-based modelling of habits in urban mobility. In *GAMA Days 2021*, 2021.
- [2] A. Jacquier and C. Adam. Choix de mobilité : une approche SMA. In *SAGEO*, pages 127–138, May 2021.
- [3] P. Taillandier, B. Gaudou, A. Grignard, Q.-N. Huynh, N. Marilleau, P. Caillou, D. Philippon, and A. Drogoul. Building, composing and experimenting complex spatial models with the gama platform. *GeoInformatica*, 23(2):299–322, 2019.

Enhancing participation in the sustainable development in the Bac Hung Hai irrigation system (Vietnam)

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Keywords

Participatory simulation, serious game, waste management, awareness-raising activities

Abstract

A current trend is to increasingly involve stakeholders in natural resource management issues. Indeed, systematic reviews show an increasing corpus of scientific literature on the subject of public participation [2]. These new scientific approaches to sustainable development rely on the general framework of Arnstein's Ladder [1], although its logics are constantly revisited [3]. Public participation is built through numerous and various methodologies. Participatory modelling is one of them [4]. Its goal is to use models as temporary tools to foster participation.

This work presents an example of such a use. More specifically, we have built a computerized serious game based on an agent-based model aiming at making farmers and local authorities of the region of Bac Hung Hai (Vietnam) reflect on waste management issues. The model was built by a team composed of both social and computer scientist on the base of an interview campaign with local stakeholders. It proposes to players to play the role of 4 local decision makers in a fictitious environment having properties close to real environments.

Each player must decide on actions to be carried out on its territory, such as changing the waste collection policy, draining the canal, or setting up awareness-raising activities. Their goal is both to limit pollution and to ensure high agricultural production. The game was designed as to show the interest of coordinated actions to deal with the waste management issue, as well as foster the farmers' empowerment in raising their voices.

In technical terms, the game is presented in a hybrid form, both physical and computerized: the game being intended to be played by stakeholders not necessarily at ease with computers, the choice was made to let them take actions in the form of physical cards. Once the action cards are chosen, the simulator can automatically scan them and take into account the actions chosen by the player. The scanning of the cards is done with a new plugin for GAMA that allows to read the QR-code written on the cards. Once all the players have chosen their action, the simulator will then simulate the dynamics of the system for one year and present to the players a pollution map as well as a set of local and global indicators (pollution, agricultural productivity).

References

- [1] Sherry R Arnstein. A ladder of citizen participation. *Journal of the American Institute of planners*, 35(4):216–224, 1969.
- [2] Olivier Charnoz. The global discourse on 'participation' and its emergence in biodiversity protection. Technical report, AFD Working Paper, 2009.
- [3] Scott Davidson. Spinning the wheel of empowerment. *Planning*, 1262(3):14–15, 1998.
- [4] Michel Étienne. *La modélisation d'accompagnement: une démarche participative en appui au développement durable*. éditions Quae, 2010.

Exploring a MBTI-based agent model in a Buyer-Seller Scenario

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Keywords

Multiagent systems, BEN, MBTI, Human Behavior, BDI.

Abstract

The simulation of human behavior through computational models has allowed a significant advance in observing certain characteristics of individuals in different contexts, such as work environments. In particular, multi-agent based simulations allow observation of important social behavior using architectures and models that better represent decision-making processes similar to human beings. The development of BDI (Belief-Desire-Intention) models [4] helps to create artificial agents with characteristics similar to the way we understand people's reasoning. BDI architectures may be expanded by adding modules representing emotions, social relationships, behaviors, and personalities. As an example, the BEN (Behavior with Emotions and Norms) architecture [1] is based on the BDI model and has supported the evolution of studies that seek to simulate human aspects through agent-based models. With BEN, it is possible to represent different characteristics, such as individuals' personalities, using the OCEAN model [2] as a basis for defining agents' personalities. Having its implementation in the GAMA modeling and simulation platform, BEN can be used through the *simple_bdi* package, which simplifies its use in several simulation scenarios. Given its flexibility, BEN can also be adapted through customized modules, for instance, to represent other personality models. In this work, we propose a customized model integrated into the BEN architecture that uses MBTI (Myers-Briggs Type Indicator) [3] as a personality model. The main objective is to study the behavior of agent teams in scenarios similar to those found in work contexts. We explored the model in a Seller-Buyer scenario [5], where Seller agent teams have the mission of selling products to Buyer agents spread throughout the environment, and these later must buy the products offered as long as there is demand for purchase. Seller agents have MBTI-inspired personality types, which decisively influence their decisions, and their behaviors can impact the team's overall performance. We seek to analyze how different compositions of personality types of agent teams could impact overall performance, in particular verifying how some specific features of the model could influence the results achieved by the teams. Tests were made in different scenarios inspired by the Law of Supply and Demand. In this way, we seek to contribute to a better understanding of factors that could be related to the behaviors presented by the agent teams, supporting an understanding of the main characteristics that may influence the results achieved.

Additional material

References

- [1] Bourgais, M., Taillandier, P., and Vercoeur, L.: Ben: An agent architecture for explainable and expressive behavior in social simulation. In International Workshop on Explainable, Transparent Autonomous Agents and Multi-Agent Systems (pp. 147-163). Springer, Cham. (2019)
- [2] McCrae, R. R., and John, O. P.: An introduction to the five-factor model and its applications. *Journal of personality*, 60(2), 175-215. (1992)
- [3] Myers, I.B., McCaulley, M.H., Quenk, N.L., Hammer, A.L.: MBTI manual: A guide to the development and use of the Myers-Briggs Type Indicator. Consulting Psychologists Press Palo Alto, CA (1998)
- [4] Rao, A.S. and Georgeff, M.P.: BDI Agents: From Theory to Practice. In Proceedings of the First International Conference on Multiagent Systems, June 12-14, 1995, San Francisco, California, USA (pp. 312-319). MIT Press. (1995)
- [5] Braz, L.F., Bachert, C.M.D.A., and Sichman, J.S.: Simulating Work Teams using MBTI agents. In: Proceedings of the 23th. International Workshop on Multi-Agent Based Simulation (MABS 2022), Auckland, New Zealand. (2022)

Handling multi-level agent-based models with GAMA

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Keywords

multi-level agent-based model, multi-level modeling

Abstract

Agent-based modelling (ABM) has been successfully used, since its emergence in the 1990s, to model and simulate the dynamics at work in complex socio-environmental systems, in many domains and applications where the interactions between populations and their environments give rise to emerging phenomena that are difficult to study differently (urban planning, land-use change, adaptation to environmental changes, protection of biodiversity in socio-ecosystems, environmental pollution control, etc.)

The inclusion of multiple levels of analysis, abstraction and representation in these models is, however, much more recent and is still the subject of numerous proposals and discussions within a relatively informal field, multilevel agent-based modelling (ML-ABM), which is most often presented as an approach that extends the classic ABM paradigm to include multilevel concepts.

This presentation proposes to explore the different tools already implemented in the GAMA Platform to create ML-ABM, their limitation and planned future development for those features.

Tangible Swarm: A visualization toolbox for swarm robotics experiments

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Keywords

Swarm robotics; Data visualization; Cyber-physical system; Complex systems debugging;

Abstract

Swarm and multi-robot systems have the potential to revolutionize many industries, from last-mile delivery to mobility networks. However, debugging these systems, especially when many robots are involved, remains an extremely complex task. To better understand the behavior of these systems, we built a visualization tool called *Tangible Swarm* [1]. This tool collects relevant information from the robots in real-time and displays it on the robots' physical workspace while the system is physically conducting its mission. Tangible Swarm is a closed-loop cyber-physical system consisting of a camera that processes sensor information (e.g., tag tracking, pattern recognition), an agent-based simulator that performs computation (e.g., calculating distances between robots), and a projector that performs actuation (e.g., projecting visual cues in the robots' physical workspace). Information such as robot IDs, sensor inputs, robot trajectories, battery status, and communication patterns can be easily displayed and customized for different missions and scenarios, such as novel robotic art installations and dynamic urban scenarios [2]. Detailed information about the system setup as well as configuration parameters can be found in the supplementary material of the paper titled "Secure and secret cooperation in robotic swarms" [3].

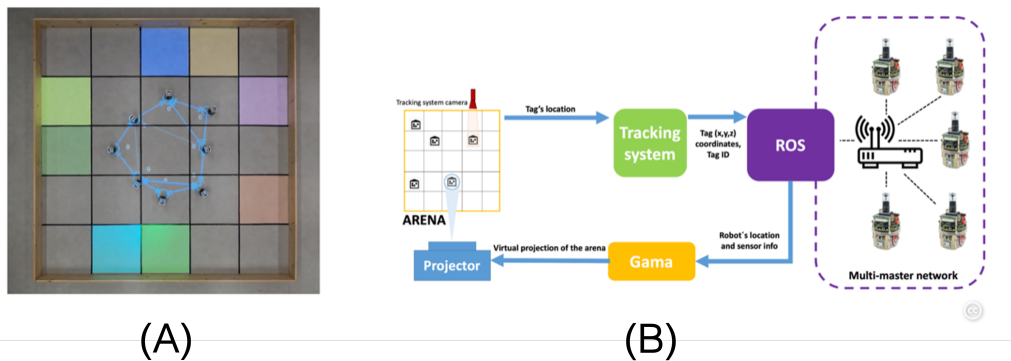


Figure 1: (A) Bird's eye view of the arena built to conduct the experiments in [3]. (B) Information workflow of the proposed tool: (i) each robot carries a tag encoding a specific robot ID. (ii), tags are recognized by a vision-based tracking system using a camera right on top of the arena. (iii), (x,y,z) coordinates for each tag are calculated and sent to a ROS multi-master network where the robots are connected in a decentralized manner. (iv), robots publish information such as their battery level, neighbor IDs, sensor inputs, etc. into this network. (v), this information is extracted from the network and sent to Gama. (vi), Gama creates then a virtual representation of the current state projected on the arena.

References

- [1] Tangible Swarm. www.media.mit.edu/projects/tangible-swarm/overview/. Accessed: 2022-06-01.
- [2] Antonio Luca Alfeo, Eduardo Castelló Ferrer, Yago Lizarriar Carrillo, Arnaud Grignard, Luis Alonso Pastor, Dylan T Sleeper, Mario GCA Cimino, Bruno Lepri, Gigliola Vaglini, Kent Larson, et al. Urban swarms: A new approach for autonomous waste management. In *2019 International Conference on Robotics and Automation (ICRA)*, pages 4233–4240. IEEE, 2019.
- [3] Eduardo Castelló Ferrer, Thomas Hardjono, Alex Pentland, and Marco Dorigo. Secure and secret cooperation in robot swarms. *Science Robotics*, 6(56):eabf1538, 2021.

S-at-work: a job satisfaction agent-based simulation model

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Keywords

Job Satisfaction, Attitude at work, social simulation

Abstract

Job satisfaction is a major determinant of global well-being, pro-social behavior or productivity among many aspect of work organisation and life. On the contrary unsatisfied workers are prone to develop bad health conditions, such as anxiety or cardiovascular disease, with negative externalities for work organisation, such as turn-over or absenteeism. To know the mechanisms that makes someone happy at work is thus a crucial aspect for the workers, work organization and health institutions. The S-at-work simulation model proposes a virtual laboratory to test socio-psychological theoretical claims about job satisfaction. More precisely we modeled three theories: the discrepancy model, where the level of satisfaction results from the comparisons of perceived job characteristics toward standards, the job attitude, where the attitude toward the job is the outcome of emotional, cognitive and behavioral states, and the vitamin model that defines the direct contribution of work aspects on workers happiness. In this presentation we introduce the model and an application to the work context of UE, using open data surveys. Then several analysis strategies will be discussed and first results introduced. Lastly preliminary results will be introduced and discussion for further development opened.

Additional material

<https://github.com/chapuisk/S-at-work.git>

Using Gama in the field to support a companion modeling approach

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Keywords

Participatory simulation, companion modeling, role playing games

Abstract

Context: Amazonian floodplains are the most populated rural areas in central Amazonia. There are one of the richest biodiversity hosts on earth, while being historically associated with human settlements practicing subsistence agriculture and fishing. Over the past decades, commercial jute cultivation, commercial fisheries, and the expansion of cattle ranching have disrupted traditional patterns of resource use. In coming years, they will be increasingly threatened by development projects and agricultural expansion, as well as by climate changes.

Problematic: One of the main goals of the BONDS project is to provide insight on floodplains management to design development strategies that consider biodiversity issues and socio-ecological dynamics together. Our primary objective is to engage stakeholders at looking for solutions in fisheries management and land use strategies, enabling preservation of biodiversity and fundamental ecosystem services, such as food security, water quality or carbon storage in Amazon floodplain environments under different hydroclimatic scenarios.

Methods: A companion modeling approach have been implemented with two main activities. In the first hand, a focal group in Santarem (Para state, Brazil) co-construct a role-playing game to build a mutual understanding of fishermen problematics, and in the second hand, the game is played in communities of the floodplain to support social learning and capacity building, collect feedback and improve the game. This enable the design of a simple model from the bottom-up and will support the development of an agent-based model of a broader scope and scale to study prospective floodplain socio-economical activities management scenario.

Proposal: In this communication we summarize the field work carried out with the focus group and communities of the floodplain. We briefly explain principle of the methodology, content of the current state of the game and how it is link to the conceptual agent based model. Last we report the usage made of the Gama platform during the field work and how it has shaped (or not) the participatory modeling phase, the game and the conceptual model.

Additional material

bonds-amazonia.org

Integrating the Theory of Planned Behavior in a Belief Desire and Intention context. An application to residential waste sorting

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Keywords

Municipal waste - Recycling – Waste separation - Behavior, Desire, Intention (BDI) – Theory of Planned Behavior (TPB)

Abstract

Considering the current climate emergency, improving how resources are being used has never been as crucial. The linear economic model, based on a ‘take-consume-dispose’ logic is close to produce irreversible damage to our planet and in order to reduce the probability of experiencing adverse climate conditions it is imperative to meet the Paris Agreement targets. One way to decouple economic growth from environmental deterioration is to improve how resources are managed at the end of their life cycle and as the world continues its process of urbanization, cities need an efficient waste management system to secure a safe and healthy habitat.

Previous research has successfully proven that the Theory of Planned Behavior (TPB) [1] can be used to describe how self-reported behavior towards waste recycling is formed, however the link between self-reported and actual behavior remains unclear. ABMs can contribute to establish a connection between actual waste recycling behavior and what residents self-declare to do. They offer an adequate platform for making this connection explicit by exploring the dynamics of the system. Moreover, granular information (spatial and temporal) about municipal waste generation is limited and hinders the capability of urban planners of making informed decisions to improve the resources that can be retrieved in city-regions. A simulation can be of help by synthesizing relevant information.

The aim of this research is to provide a better understanding not only how much and what type of waste is being generated, but also when and where it is being generated. Given the complexity and interactions within the system of waste management this study proposes an ABM to simulate the present decision to recycle. The implementation of the model was done in GAMA because of its spatial capabilities and the possibility of providing a cognitive architecture to its agents. The agents in the model are residents of an area and they are encoded with Belief, Desires and Intention (BDI) capabilities [2]. Empirical information derived from a TPB questionnaire is used to calibrate the priority of how agents make decisions (plans). By interacting with other agents and perceiving their environments, residents update their knowledge base and consequently change their plans.

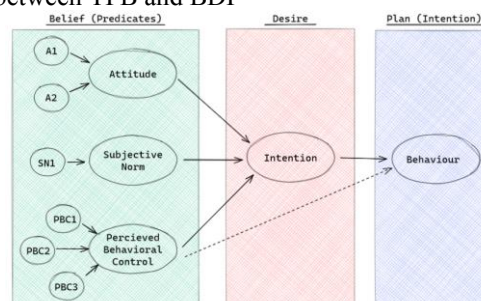
The contribution of this paper is twofold: (i) to integrate the theory of planned behavior into the BDI architecture, (ii) towards developing a spatially explicit agent-based model about waste separation. Since the model relies on the TPB, it demonstrates how to integrate it with the existing behavioral architecture (BEN). As a next step, the model will be calibrated, and different planning scenarios will be tested to evaluate how urban planners (location and maintenance of infrastructure) can increase the number of resources and the quality that is currently being retrieved in cities.

- [1] I. Ajzen, “The theory of planned behavior,” *Organ. Behav. Hum. Decis. Process.*, vol. 50, no. 2, pp. 179–211, Dec. 1991, doi: 10.1016/0749-5978(91)90020-T.
- [2] M. Bourgaïs, P. Taillandier, and L. Vercouter, “Ben: An architecture for the behavior of social agents,” *Jasss*, vol. 23, no. 4, pp. 1–26, 2020, doi: 10.18564/jasss.4437.

Additional material

GitHub repository: https://github.com/Urban-JonathanCohen/Waste_sorting_ABM

Figure shows how the correspondence between TPB and BDI



Toward A Multi-Leveled Coordination Of Sub-Models In Spatial Model Coupling

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Keywords

Agent-Based . Coordination . Heterogeneity . Simultaneous Actions. Spatial Model Coupling

Abstract

The soil is a highly heterogeneous system where numerous processes interact and provide ecosystemic services. Spatial model coupling proposes to represent such system by classifying existing processes as a sub-model and determining interaction rules (between sub-models) using the space as a communication media. Such modeling approach is quite intuitive for the modeler. Nevertheless, it requires a conflict management protocol. For example, a sub-model acting at a macro level should affect dynamics realised at a micro level by sub-models. Therefore, conflicts occur when resources of the space cannot support the demands. In order to maintain the coherency of the simulation, these conflicts have to be managed at various levels.

We promote a spatial oriented coupling approach allowing the space to manage conflicts between sub-models. We used the Influence and Reaction principle from [Ferber and Müller, 1996] to formalize sub-model interactions. A Coordination Unit manages, analyses interactions and their impact on the space then detect conflicts and resolve them by using negotiation protocols.

This approach has been implemented as a Gama plugin and tested on a homogeneous space. Comparative results suggest that using the Coordination Unit gives more precise indication on how resources of the space are consumed by sub-models compared to the other model in which the conflict management system was not implemented. However, the approach has to be adapted for multi-level configuration in order to fit soil modeling purposes. To do so, we discuss in this paper which methods can be added to our model coupling approach to fit our modeling needs.

Additional material

References

[Ferber and Müller, 1996] Ferber, J. and Müller, J.-P. (1996). Influences and reaction: a model of situated multiagent systems. In *Proceedings of second international conference on multi-agent systems (ICMAS-96)*, pages 72–79.

An Affordance-Based Multi-Agent Simulation to Constrain Emergence

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Keywords

Affordance, Multi-Agent Simulation, Emergence

Abstract

Today, metropolitan areas are marked by a phenomenon of urban growth and densification, leading to significant congestion and mobility problems. The urban development of new neighborhoods in the city, therefore, requires upstream planning of the various means of access, in particular in terms of public or shared transport modes. Tools for analyzing the structure of the urban fabric and the various transport networks, as well as their evolution[1], are now essential tools for urban planners to understand these problems. To go further and be able to test the evolution of the behavior of the inhabitants to different choices of developments, modeling, and simulation-based on agents is one of the most appropriate tools[2].

An agent-based model can represent a phenomenon at the individual level and generate emergent phenomena at the macroscopic level or mesoscopic levels. For example, the simulation of the individual mobility of users of a university campus (students, teachers, etc.) brings out patterns of attendance in teaching or catering buildings, regular at the weekly scale.

The main problem with these emerging phenomena is that they are difficult to anticipate, understand and control. This is, even more, the case at the mesoscopic level: how to ensure that certain constraints set by the modeler on areas of the environment are satisfied while preserving the autonomy of individual agents (microscopic level) in their choice of behavior?

We describe in this paper a novel approach allowing the modeller to specify its macroscopic or mesoscopic constraints directly in some entities of the environment that will influence the behavior of individuals. The idea is to allow the modeler to specify directly in the model the interactions that he wants to be able to observe at a macroscopic level. We define two agent roles, the Enabler, which offer certain action potentialities, and the Consumer who can achieve them. We base our model on the concept of Affordance and propose a first implementation on the Paul Sabatier Campus. The main purpose is to allow an urban developer, with certain business knowledge, to come and specify the interactions he wishes to observe, such as the attendance of buildings.

Additional material

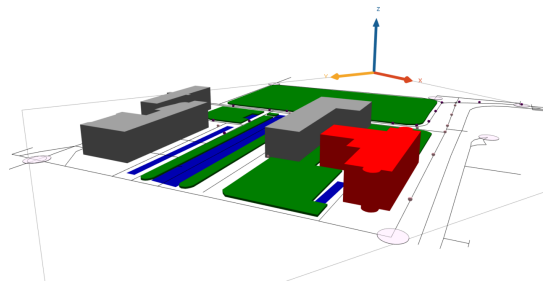


Figure 1: Capture d'écran de la simulation sur le campus

References

- [1] M. Barthelemy. *The structure and dynamics of cities*. Cambridge University Press, 2016.
- [2] A. T. Crooks, A. Patel, and S. Wise. Multi-agent systems for urban planning. In *Technologies for urban and spatial planning: virtual cities and territories*, pages 29–56. IGI Global, 2014.

A modular framework for multi-behavior and multi-scale simulation of pedestrians

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Keywords

Pedestrian dynamic, agent-based framework, multi-scale modeling, multi-level behaviors

Abstract

Crowd simulation has been the subject of intensive research over the past two decades, and this work has produced successful findings in a wide range of applications, including computer graphics, urban planning, and many more. The modeling of crowds in high-density situations, however, remains a challenge for researchers. The majority of cutting-edge methods concentrate their attention on the operational level, which is where pedestrians adapt their behavior to prevent local collisions with their neighbors while maintaining their primary path to their objective. In densely populated environments, it is necessary to carry out in-depth research into higher levels of behavior: strategic and tactical levels [1], at which pedestrians decide where they want to go and how to choose a route to the predefined destination. Here, we introduce a modular framework that allows modelers to dynamically incorporate a variety of modeling techniques to simulate the multi-level behaviors of pedestrians. In addition to that, this framework is able to perform multi-scale simulations, which means that in the same environment, individuals, groups, and flows may all be taken into consideration. Finally, we present a set of applications in order to demonstrate the capability of the framework.

Acknowledgement

The work is a part of the Franco-German research project MADRAS funded in France by the Agence Nationale de la Recherche (ANR, French National Research Agency), grant number ANR-20-CE92-0033, and in Germany by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation), grant number 446168800.

References

- [1] Serge P Hoogendoorn and Piet HL Bovy. Pedestrian route-choice and activity scheduling theory and models. *Transportation Research Part B: Methodological*, 38(2):169–190, 2004.

Gampy: a fast plugin for integration of Python-based deep-learning models to the GAMA platform

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Keywords

Simulation, deep learning, Gama plugin, Python integration, intelligent behavior

Abstract

In recent years, deep learning and simulation have come to receive a significant amount of focus from researchers. A great deal of work has gone into connecting these two fields, however, merging them is not something that can be accomplished quickly. The majority of those possible combinations include using the results of the simulation as input for deep learning, or vice versa. There are not yet many possible mixtures in which the agent possesses an innate capacity for deep learning, which would contribute to the agent's more intelligent behavior. In addition, the majority of deep learning models are built with Python, whereas the GAMA platform [1] and NetLogo [2] are frequently used to create simulation models. As a means of bridging these two domains, we present Gampy - a GAMA plugin that assists in the integration of a deep-learning model that has been pre-trained in Python. The agent has been updated to provide a predictive capability that makes use of models trained from Python deep learning frameworks (Tensorflow/Keras [3, 4] and Pytorch [5]). Moreover, we demonstrate the efficiency of this plugin by showcasing a few different applications. The findings reveal that Gampy's execution time outperforms alternative networking approaches.

Additional Material

The plugin has been uploaded to the GAMA experimental plugin repository: <https://github.com/gama-platform/gama.experimental>

Acknowledgement

The work is a part of the Franco-German research project MADRAS funded in France by the Agence Nationale de la Recherche (ANR, French National Research Agency), grant number ANR-20-CE92-0033, and in Germany by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation), grant number 446168800.

References

- [1] Patrick Taillandier, Benoit Gaudou, Arnaud Grignard, Quang-Nghi Huynh, Nicolas Marilleau, Philippe Caillou, Damien Philippon, and Alexis Drogoul. Building, composing and experimenting complex spatial models with the GAMA platform. *Geoinformatica*, 23(2):299–322, December 2018.
- [2] Seth Tisue and Uri Wilensky. NetLogo: A simple environment for modeling complexity. In Ali Minai and Yaneer Bar-Yam, editors, *Proceedings of the Fifth International Conference on Complex Systems ICCS 2004*, pages 16–21, 2004.
- [3] Martín Abadi, Ashish Agarwal, Paul Barham, Eugene Brevdo, Zhifeng Chen, Craig Citro, Greg S. Corrado, Andy Davis, Jeffrey Dean, Matthieu Devin, Sanjay Ghemawat, Ian Goodfellow, Andrew Harp, Geoffrey Irving, Michael Isard, Yangqing Jia, Rafal Jozefowicz, Lukasz Kaiser, Manjunath Kudlur, Josh Levenberg, Dandelion Mané, Rajat Monga, Sherry Moore, Derek Murray, Chris Olah, Mike Schuster, Jonathon Shlens, Benoit Steiner, Ilya Sutskever, Kunal Talwar, Paul Tucker, Vincent Vanhoucke, Vijay Vasudevan, Fernanda Viégas, Oriol Vinyals, Pete Warden, Martin Wattenberg, Martin Wicke, Yuan Yu, and Xiaoqiang Zheng. TensorFlow: Large-scale machine learning on heterogeneous systems, 2015. Software available from tensorflow.org.
- [4] François Chollet et al. keras, 2015.
- [5] Adam Paszke, Sam Gross, Francisco Massa, Adam Lerer, James Bradbury, Gregory Chanan, Trevor Killeen, Zeming Lin, Natalia Gimelshein, Luca Antiga, et al. Pytorch: An imperative style, high-performance deep learning library. *Advances in neural information processing systems*, 32, 2019.

Investigating Synthetic Pedestrian Data Generation to Improve Mobility Patterns Recognition of Citizens for Smarter Cities

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Keywords

Synthetic Data Generation, Mobility Patterns, Smart City, CTGANs, Digital City Science

Abstract

Recognizing the mobility pattern of citizens is one of the important aspects of "Smart City" qualities. Pedestrian movement prediction in newly built urban areas requires data explorations and evaluations. Data-related urban systems such as traffic management, environmental monitoring, etc. The usage of urban data opens immense possibilities, and their potential use cases are promising. But it is constrained by the challenges of security and privacy, availability, data quality, and cost issues. The usability of existing methods for data generation is often limited. Processing the data which is needed for those methods can have high costs or might be planned for specific areas of application. As an alternative solution to the above dilemma, the generation of synthetic data has importance for the cases where real training data is not available. Our contribution presents an overview of the data preparation and processing in order to investigate the trust-able synthetic data production by using the simulation of pedestrian tabular data about demographic and location results of the Grasbrook model [1] which is based on the GAMA platform and validated by real-world pedestrian activity data of Hafencity. Hafencity is a new district, which is almost completed and densely populated. Grasbrook is a new urban district under development. The case study from the model of Hafencity has been chosen. For this case, we validated the consistency and quality of the samples and identified issues with the pedestrian data synthetic generated. Overall, pedestrian paths that are not looking like real ones were identified. After the validation, our research suggests Deep Learning (DL) and Data science approaches can be applied to tackle the issues and improve the synthetic pedestrian samples. Specifically, Conditional Tabular Generative Adversarial Network (CTGANs) [2] is able to generate tabular data, which means rows and columns of information about pedestrians (e.g. age range, latitude, longitude, etc). In this research, the use of CTGANs and data handling techniques are explored to improve the quality of the data for better pedestrian route generation. One particular case that was identified is the imbalance of the data, where we observed classes of an information column in the pedestrian data with an uneven distribution of observations (e.g. pedestrians that work or live in the residential Grasbrook area, age range, etc). The imbalance of classes of every column identified could be solved using the CTGANs approach. This can lead to obtaining a dataset with more variety of examples and a more equal representation of all classes. The results after applying the suggested techniques might show the innovation potential of the GANs methods (CTGANs) as a new feature to improve the quality of simulation outputs in table form.

Additional material

Data set: <https://cloud.hcu-hamburg.de/nextcloud/s/CYf5c8HdQf3SpHW>

This work is part of the DaFne project. We want to thank Dr. Jesús López Baeza for the guidance and providing the data set used in the experiments.

References

- [1] Jesús López Baeza, Jose Carpio-Pinedo, Julia Sievert, Andre Landwehr, Philipp Preuner, Katharina Borgmann, Maša Avakumović, Aleksandra Weissbach, Jürgen Bruns-Berentelg, and Jörg Noennig. Modeling pedestrian flows: Agent-based simulations of pedestrian activity for land use distributions in urban developments. *Sustainability*, 13:9268, 08 2021.
- [2] Lei Xu, Maria Skoularidou, Alfredo Cuesta-Infante, and Kalyan Veeramachaneni. Modeling tabular data using conditional gan. *Advances in Neural Information Processing Systems*, 32, 2019.

Distribution of Gama model with MPI

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Keywords

Distribution, Parallelization, Message Passing Interface, Synchronization

Abstract

In the field of simulation, we often seek to push the limits, that is, to analyze larger and more accurate models to get closer to the reality of a problem.

The increase of the precision or the size of the simulated models has a direct impact on the amount of computation to be done.

Unfortunately, centralized architectures are no longer or not sufficient to run simulations. Indeed, when executing large models, centralized systems suffer from a lack of memory or computing power. The use of parallel resources, in example, the use of high-performance computing (HPC), becomes necessary in order to overcome the limitations of centralized systems and thus increase the size or accuracy of the simulated model. If simulation on a single computer is often complex, the parallel execution of a simulation is a real challenge.

New problems appear with the use of parallel resources, such as synchronization between all the entities of the cluster to access data of the distributed model.

This presentation will present some of these solutions to counter the problem of synchronization/data sharing for Gama model in a cluster-based environment.

Optimizing the spatial configuration to reduce covid-19 infection in commercial districts using multi-scale modeling. Use case Lima, Peru

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Keywords

Covid-19, Non Pharmaceutical Intervention, Agent-based modeling.

Abstract

The health crisis related to covid-19 raised many questions about its management. Non Pharmaceutical Interventions (NPIs) are often used in order to reduce the transmission of the disease, avoid hospital congestion, etc. But those measures are harmful to economical and social life. Beside, it is not possible to shut down essential activities such as food supply or healthcare. As a consequence, it is necessary to set up NPIs that allow to maintain those activities. In the city of Lima (Perú), the areas of Mirones Bajo and Mesa Redonda host vital activities: Mesa Redonda is a large open market which is the main hub for food and primary supplies. It is permanently heavily crowded and cannot be shut down. As a result, it is necessary to define measures to limit the risk of transmission by reducing the contact between people. In order to do so, we design an agent based model which goal is to identify crowd flow control and schedule strategies in order to minimize the global risk of transmission, under the constraint of keeping a steady level of activities.

A key problematic in terms of modeling methodology is that commercial areas consist of heterogeneous zones with different scales and crowd densities: Mesa Redonda is a wide open market with commercial streets around a closed three-story central market building. Therefore it is required to rely on multi-scale modeling, allowing to represent both large-scale open urban areas and closed built environments with a high density of activities. In order to address this issue, we present a multi-agent model that can be scaled at three different levels: the district level (use case of Mirones Bajo), the neighborhood level (Mesa Redonda open market) and the building level (Mesa Redonda central market).

In this model we use the COMOKIT framework [1] dedicated to simulating the spread of a disease among a population using agent based models, and the Proxymix framework [2], which is a more detailed extension of COMOKIT that allows a detailed representation of the transmission in closed built environments. This framework allows to explore different NPIs scenarios such as individuals schedules changes, health barrier gesture, face masks, roads closing or crowd flow containment. We feed the model with data obtained from Lima authorities about people behaviors, and crowd flows count. We then (1) identify high risk of contamination areas and (2) determine a flow pattern (blocked roads, one way roads) that minimize the global exposition to the virus.

References

- [1] Benoit Gaudou, Nghi Quang Huynh, Damien Philippon, Arthur Brugière, Kevin Chapuis, Patrick Taillandier, Pierre Larmande, and Alexis Drogoul. Comokit: A modeling kit to understand, analyze, and compare the impacts of mitigation policies against the covid-19 epidemic at the scale of a city. *Frontiers in public health*, page 587, 2020.
- [2] Arnaud Grignard, Tri Nguyen-Huu, Patrick Taillandier, Luis Alonso, Nicolas Ayoub, Markus Elkatsha, Gamaliel Palomo, Monica Gomez, Mario Siller, Mayra Gamboa, et al. Using agent-based modelling to understand advantageous behaviours against covid-19 transmission in the built environment. In *International Workshop on Multi-Agent Systems and Agent-Based Simulation*, pages 86–98. Springer, 2021.

An Interactive Game for Flood Evacuation Planning based on GAMA Simulation

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Keywords

participatory modeling, crisis management, geographic information system, decision support system, agent-based simulation

Abstract

Flood is one of the most frequent and severe natural disasters, especially in tropical regions. Short-notice disasters can cause massive loss of life and property due to the lack of preparation, unclear perception of situations, non-compliance with instructions, and inadequate experience. Here we developed an interactive serious game for cooperative flood planning with agent-based simulation models using the GAMA platform integrated with realistic flood scenarios calculated from 2D flood models. The game is designed to be played participatory with stakeholders such as responsible authorities, volunteers, and evacuees. The players are involved in defining the population, responsibilities, resources, and activities in the agent-based evacuation model. The game simulates realistic flood scenarios and interactively responds to each decision made by the player during the process which leads to different results. This game can be used as a support system for decision-makers and as a cooperative tool to establish a common understanding among the stakeholders to reduce improvisation and chaotic responses in the real situation.

Using synthetic data to improve performance of data-driven algorithms in high density pedestrian situations

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Keywords

synthetic data, crowd behavior, deep learning, trajectory prediction, agent-based modelling

Abstract

In recent years, there has been a rising interest in pedestrian trajectory prediction methods. The advancement of machine learning algorithms and real-world applications, such as autonomous vehicles or social robots, are reasons for that. These methods mainly focus on learning local interactions and single pedestrian trajectory prediction over a relatively short time horizon. To learn these interaction behaviors, the algorithms are trained with data taken from low-density situations where just a few pedestrians are involved.

In our work, we aim to investigate how supervised machine learning methods can address crowded pedestrian situations. For this task, high-density trajectory data-sets are necessary. To the best of our knowledge, there exist, however, only few available real-world data-sets containing dense situations. To overcome the lack of data, we train the algorithms on experimental data [1] as well as synthetic data generated by running simulations in the GAMA platform [2]. In previous studies, error-metrics like the average-displacement error (ADE) or final displacement error (FDE) allow quantifying the prediction accuracy [3]. However, we argue that these metrics are not sufficient for high-density situations. Indeed, dense dynamics are mainly governed by physical body-exclusion of the pedestrians. Yet, ADE and FDE metrics do not account for such features. Instead, we propose an evaluation process consisting of three phases. First, the predictions are visualized in GAMA to qualitatively assess how realistic the pedestrians behave. Second, the ADE, FDE, and the number of collisions (overlappings) that occur in the predicted trajectories are analysed. Especially the last metrics is important for high-density situations. In the last step, we compare the predicted pedestrian flow/density relationship to the fundamental diagram of experimental data [4]. By using this mixture of quantitative and qualitative metrics, the performance of the algorithms can be better evaluated.

Acknowledgement

The work is a part of the Franco-German research project MADRAS funded in France by the Agence Nationale de la Recherche (ANR, French National Research Agency), grant number ANR-20-CE92-0033, and in Germany by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation), grant number 446168800.

References

- [1] Pedestrian Dynamics Data Archive. <https://doi.org/10.34735/ped.da>. Accessed: 2012-05-22.
- [2] Patrick Taillandier, Benoit Gaudou, Arnaud Grignard, Quang-Nghi Huynh, Nicolas Marilleau, Philippe Caillou, Damien Philippon, and Alexis Drogoul. Building, composing and experimenting complex spatial models with the GAMA platform. *Geoinformatica*, 23(2):299–322, December 2018.
- [3] Alexandre Alahi, Kratarth Goel, Vignesh Ramanathan, Alexandre Robicquet, Li Fei-Fei, and Silvio Savarese. Social lstm: Human trajectory prediction in crowded spaces. In *Proceedings of the IEEE conference on computer vision and pattern recognition*, pages 961–971, 2016.
- [4] Shuchao Cao, Armin Seyfried, Jun Zhang, Stefan Holl, and Weiguo Song. Fundamental diagrams for multidirectional pedestrian flows. *Journal of Statistical Mechanics: Theory and Experiment*, 2017(3):033404, 2017.

BDI Model for Simulating Governance in Decentralized Autonomous Organization

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Keywords

Belief-Desire-Intention (BDI), blockchain, Decentralized autonomous organization(DAO), agent-based modeling, eGovernment, organization design

Abstract

Agent-based modeling is widely used for geospatial modeling in the field of urban planning, including transportation, epidemic transmission, etc., but is rarely applied to social relations modeling that leads to urban policy or organizational design. In the web3.0 era, the Decentralized autonomous organization (DAO) has emerged as a new form of organization that computerized the rules of governance and is controlled by organization members based on the immutable and decentralized smart contract. Due to its novel structures and functions, the number of active DAOs is exploding, expecting to promote societies' democracy, fairness, and trustfulness. Besides, DAO's complexity and underlying mechanism present challenges for founders seeking evidence of the rationality of their initial governance designs. Although DAO's governance design has received academic and practitioner attention, there is still a lack of theories or simulation models ensuring that its governance is valid. Besides, existing models in the literature did not consider the heterogeneity and social connections in DAO's communities. Therefore, the agent-based modeling(ABM) and Belief-Desire-Intention(BDI) paradigm become a natural choice for governance simulation considering different stakeholders.

This article presents an agent-based modeling approach with the aim of simulating individual decision-making, the voting process, and the token economy in a DAO based on the GAMA platform. The Belief-Desire-Intention(BDI) agent in GAMA is utilized to introduce DAO members' interaction and individual features, that have not been considered in existing literature, into this model. In the first place, the goal of DAO members is to maximize the token amount, and we model such a multi-agent system as an incomplete information game theory. On top of that, we explore how will information exchange, social relations, and personal inner state influence members' voting and decision-making. Then, the agents were presented as existing DAO members or potential members by abstracting their various characteristics into personas. Besides, this approach also models token trading through brown motion in a free market with member entry and exit. Apart from that, our model builds indicators of governance performance, including user engagement, governance equity, and the stability of the token economy. Apart from that, this model is applied in the case of the DAO that facilitates fractional ownership in real estate and achieves the goal of affordable housing to evaluate its governance design.

This study fills the gaps of complex DAO governance simulation by implementing agent-based modeling, which enables to determine whether a DAO is robust and sustainable in advance. Besides, based on BDI architecture, the effects of user heterogeneity, inner state, and interactions are considered to promote the practicability and accuracy of this simulation. Finally, this approach simulates the governance design of a fractional ownership DAO which shows a good result, leading to a new tool for facilitating DAO's governance design to enhance equity, democracy, and efficiency.

Additional material

SoCity DAO Homepage: <https://www.socitydao.org/>

SoCity DAO Discord: <https://discord.com/invite/cWvjzbGwE>

SoCity DAO Deck: <https://urlis.net/SoCityDeck>

SoCity DAO Whitepaper: <https://urlis.net/SoCityWhitepaper>

Simulating Multi-Purpose Autonomous Vehicles: Shared Mobility between People and Goods in Kendall Square

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Keywords

Urban Mobility, Shared Mobility, Multi-Purpose Autonomous Vehicle, Agent-Based Simulation, Traffic Simulation

Abstract

According to a study by Morgan Stanley [1], the transport sector is heavily reliant on fossil fuels, accounting for 45% of global oil demand. However, autonomous vehicles (AVs) offer significant environmental benefits in fuel usage, as noted by the Southwest Research Institute study [2] claiming that AVs can lead to as much as a 20% improvement in fuel consumption. Hence, the goal of the GAMA simulation is to predict a low-carbon and efficient transportation system to shift the usage and reliance on high fossil fuel consuming vehicles to multi-purpose vehicles, to shape what an optimal transportation system in the future will look like. To accomplish this, we will introduce a Multi-Purpose Autonomous Vehicle (MPAV) Based on a modular design strategy, the MPAV is able to do tasks such as cleaning waste and delivering commercial goods. For the simulation, we simplified it to carrying people and goods (parcels and food) with two capacities.

We choose Kendall Square as a representative site for the future entrepreneurship innovative city, for it gathered a large number of high-tech enterprises that generate huge demand for parcel and food delivery from companies and commuters. Through simulation, we hope to find a balance between existing transportation options, MPAVs, and potentially other future modes of transportation to meet the transportation demands of the people of Kendall Square.

In conclusion, we have developed a simulation tool modeling a traffic system with MPAVs and taken Kendall square as a case study. The findings of our study provide a methodology to investigate different traffic scenarios and to assist the government forecast the size of deployment of new shared mobility services for passengers and packages. Besides, the simulation tool also allows for testing various transportation policy designs, such as strategies for rebalancing fleets and for distributing charging stations.

Additional material

Demo & Deck: https://www.figma.com/proto/wjzRv3QPleUfdm0NiADYeG/Mobility_Final-Presentation

Github Repo: https://github.com/LeeJAJA/GAMA_MPAV_Mobility

References

- [1] Neel Mehta et al. Adam Jonas, Paresh Jain. *Global Investment Implications of Auto 2.0*. Morgan Stanley, 2016.
- [2] Sankar Rengarajan, Scott Hotz, Jayant Sarlashkar, Stanislav Gankov, Piyush Bhagdikar, Michael C Gross, and Charles Hirsch. Energy efficient maneuvering of connected and automated vehicles. *SAE International Journal of Advances and Current Practices in Mobility*, 2(2020-01-0583):3231–3239, 2020.

The need for optimization tools in agent-based models: a GAMA model for flood crisis management

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Keywords

Agent-based modeling, optimization, simulation, flood crisis management

Abstract

The integration of agent-based modeling and simulation into decision-making tools requires enhancing their realism by supporting intelligent optimized decisions [1]. However, optimization is not a native feature of agent-based models (ABMs), and it is necessary to combine them with existing optimization tools [4]. This complementary approach, combining geospatial simulation with optimization, allows simulators to support realistic decisions that might be necessary to address real-world problems. Such simulators can help test what-if scenarios and assess alternative strategies in different domains where decision-makers need optimized solutions.

In this work, we present a simulator that couples an ABM with a Vehicle Routing Problem (VRP) optimizer [3]. This optimizer uses optimization heuristics that compute the best routes for a fleet of vehicles to minimize their total traveled distance [2]. We use this tool to optimize the evacuation of vulnerable people from risk areas during flood events. The ABM, implemented under the GAMA platform, simulates all the spatial and temporal dynamics (the environment, interactions between actors, and the evacuation process) and communicates with the VRP optimizer to obtain evacuation plans.

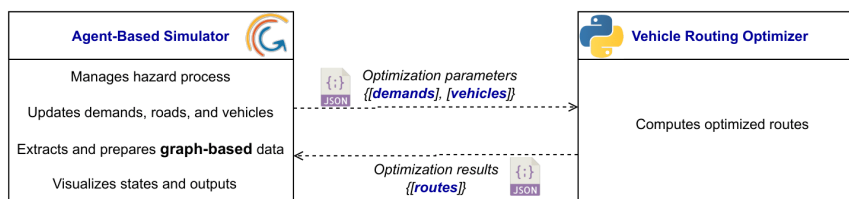


Figure 1: Coupling of the ABM simulator (GAMA) with the VRP optimizer (Python)

We apply this model to the October 2018 flood scenario in the city of Trèbes (South of France). We use the GAMA platform in graphical mode to visualize and calibrate scenarios, then in headless mode to run multiple parallel simulations with different input parameters. The aggregation of these simulation outputs helps crisis managers decide on the best evacuation strategies according to several parameters: the number of available emergency vehicles, the location of evacuation centers, and the evolution of the flood hazard. This application shows that coupling ABMs with optimization tools is relevant in addressing real-world situations. We believe that integrating optimization tools into GAMA could ease the development of such applications.

Additional material

Demonstration video: <https://youtu.be/sL5GHBmCvko>

References

- [1] Donald L DeAngelis and Stephanie G Diaz. Decision-making in agent-based modeling: A current review and future prospectus. *Frontiers in Ecology and Evolution*, 6:237, 2019.
- [2] Florent Dubois, Paul Renaud-Goud, and Patricia Stolf. Capacitated vehicle routing problem under deadlines. In *2019 International Conference on Information and Communication Technologies for Disaster Management (ICT-DM)*, pages 1–8. IEEE, 2019.
- [3] Ahmed Laatabi, Benoit Gaudou, Chihab Hanachi, Patricia Stolf, and Sébastien Truptil. Coupling agent-based simulation with optimization to enhance population sheltering. In *Proceedings of the 19th International Conference on Information Systems for Crisis Response and Management (ISCRAM)*, pages 1–17. ISCRAM, 2022.
- [4] Abolfazl Taghavi, Sharif Khaleghparast, and Kourosh Eshghi. Optimal agent framework: A novel, cost-effective model articulation to fill the integration gap between agent-based modeling and decision-making. *Complexity*, 2021, 2021.

A multi-agent simulation model to study the impact of transitioning to hormone-free reproduction management on the performance and management of a French dairy sheep flock

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Keywords

Multi-agent model, Hormone-free reproduction, Dairy sheep, Flock performances

Abstract

In dairy sheep production, the use of hormonal treatments (HT) allows the deseasoning and synchronization of all ewes in a flock for animal insemination (AI). AI is a historic pillar of the genetic progress of the Lacaune breed, the only breed authorized in the specifications of the Roquefort PDO. However, to respond to the current challenges of agro-ecology and the evolution of societal demands, the management of hormone-free (HF) reproduction in dairy sheep farming is a promising lever to be explored. The male effect (ME) is an effective HF practice to manage the reproduction of dairy ewes in sheep flocks, as it allows the resumption of the sexual cycle for ewes that were in seasonal anestrus (sexual rest). However, with the use of this HF practice, collateral impacts are to be expected in the rest of the farming system components as the efficiency of the ME for heat induction and synchronization is more uncertain compared to conventional HT. Indeed, the reproductive performance of the flock in a HF context including the use of the ME practice is subject to variability in heat onset due to the diversity of individual characteristics of the ewes such as their age, body condition or milk production level. Thus, the objective of this study was to design a multi-agent model representing the dynamic functioning of a dairy sheep farm, including a representation of the variability of the flock's response to reproductive management in HF cases, in order to simulate and compare different flock reproductive management practices (with or without hormones). The goal is to evaluate the "ex-ante" impact of alternative methods to HT on the zootechnical, economic and environmental performances of the farm to identify sustainable ways to introduce HF reproduction management practices in conventional dairy sheep farms of the Roquefort Basin in the South of France. A first multi-agent model was thus implemented using the GAMA platform and used to simulate both annual and dynamic (daily or weekly) zootechnical indicators of the farm performance under different reproduction management scenarios. Based on the reference operation of a conventional dairy farm, six reproduction management scenarios were simulated and compared over a production season. They differed i) by their reproduction period (i.e. period of the year where the reproduction occurs) and/or ii) the use (or not) of HT. In all HF scenarios, a significant reduction in the number of ewes lambing and annual milk production of the farm (-1 to -7%; $P < 0.05$) was observed. A consequent decrease in the annual nutritional requirements of the flock (-2 to -6%; $P < 0.05$) was also observed. The HF scenarios also resulted in staggered lambing, which led to a shift in the peak of milk production and, consequently, in nutritional requirements during the production season. Transitioning from conventional to HF reproduction management, would therefore involve an increase in workload and a lengthening of the scheduled milking period, as well as a readjustment of flock feeding management according to the availability of feed resources on the farm.

An Initial Model of Land Use Changes and Their Impacts in Watersheds: a case study using GAMA

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Keywords

Land use change, Multi-agent system, Hydrological modelling, Watershed

Abstract

The environmental change, generated in a region, can cause serious socioeconomic consequences. In particular, natural or anthropic changes, in watersheds, can modify the hydrological processes involved in the system. To face and prevent these impacts, actions must be planned in a sustainable and conscious way. Tools such as Multi-Agent Systems (MAS) can be useful to describe the processes of human actions in watershed regions. In this sense, this work presents initial modeling of the change in land use in the Arroio Fragata Watershed (AFW), located in southern Brazil. For this, the GAMA tool was chosen for the development of the modeling and simulation of the system, integrating data from geographical information systems. The MAS environment is the AFW, where maps of subwatersheds and land uses of the region are considered. The subwatersheds map was spatially discretized into 39 subwatersheds, according to the Lavras Simulation of Hydrology model. The land use map presents the following land use classes: agriculture, exposed soil, forestry, native forest, native field, pasture, and water. The environment was discretized in square cells, where the land use and subwatershed were determined in each cell. Cell dimensions can be defined before starting the simulation. The system agents are called managers, responsible for modifying the land use in the cells. Each agent has an intent, fixed or random, that corresponds to the objective of changing land use. The intent can be defined among four possibilities: agriculture, exposed soil, forestry, and pasture. Agents walk and change the environment according to the intent. And the number of managers can be defined from 1 to 10 by interface. Some variables were used to represent the volume of water in each simulation cycle, and the model scale was defined as monthly. In this initial model, we are considered three variables: an initial volume of water in the environment, consumption of water, and a recovery rate. For each land use, a water consumption was established and indicated in each cell. In this way, the total water consumption is updated at each cycle, according to the sum of all consumption in the environment. The system recovery rate is updated every 3 cycles, representing the total rainfall according to the season (and for the four season in the year, different values for the variables are defined). To calibrate the parameters of the recovery rate at each season of the year, the simulations were performed without changing the environment, i.e., the reference values were established in a spatially stable system. In each cycle, the water volume is updated from the previous water volume, previous water consumption, and the recovery rate. The model results achieve the expected the goals, as the agents presented the actions and changes in the environment in each cycle. In addition, it is indicated that the tool can be explored for analysis of decision making with respect to land use change. Some challenges were encountered, such as computational time, parameter calibration, and model validation.

Modeling of the behavior of a player in LittoSim

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Keywords

Modeling, AI, Markov chain

Abstract

(LittoSIM is a participative simulation device, which proceeds in the form of workshops. During a game, players interact with a simulated territory to try to set up a collective strategy of adaptation of the territory to the risk of marine submersion. The players carry out actions of land use planning and coastline defense on the simulated territory, through game interfaces developed in GAMA that include buttons for possible actions, information on available resources (mainly a budget) and information on the risk situation of their territory. In this project, I modeled the behavior of a player during a game. The objective is to develop a bot (automatic player) able to emulate the decision making of the players during the game in order to replace the human player. The project is different from traditional AI topics because we are not looking for optimization but for the most faithful correspondence possible to the actions of human players, including errors. To do so, we have to list the actions that can be performed by a player and then determine the main criteria for decision making during the game. This allows to set up a graph very similar to a Markov chain. The different combinations of criteria will give the states and the actions give the transitions. By studying the games that have already been played, we can determine the actions that are most used according to the situation, and thus increase the probability that the bot will perform these actions when it is in the corresponding state. The graph differs from an ordinary Markov chain by adding an intermediate state after each transition which corresponds to an estimated state after the action has been performed. That way, the next state does not depend only on the action performed, but also on the bot's estimation of the potential effect of the action.

In order to limit the number of states and transitions, they can be grouped. For example, states can be grouped when some criteria are ignored by the player because of their relative importance compared to other criteria. Similarly, actions can be grouped together if they are performed with the same objective. For this purpose, we grouped actions with similar effects (e.g., increase budget, decrease vulnerability to flooding). Moreover, grouping actions allows to model more complex decisions, such as a series of actions often performed in a row.

In LittoSIM, two criteria were identified, revenue and urgency to deal with flooding. By combining these criteria we obtain 8 states (low income/high urgency, good income/high urgency, low income/medium urgency...) and 8 groups of actions each comprising between 1 and 3 actions.

This modeling system allows modifying the bot profile by modifying the action probabilities for each state. For this, the method used for LittoSIM is the implementation of matrices of size $N \times M$ where N is the number of states and M the number of actions. Each cell of the matrix allows to define the probability of the action according to the corresponding state.

This contribution will focus on explaining the bot modeling approach associated with the LittoSIM device. Elements of the bot implementation in GAMA will also be presented.

Simulacres et Simulation: Using GAMA to debug a real-world genetic-epidemiology outbreak simulator

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Keywords

Ground truth dataset, COMOKIT, Operation Outbreak, evolutionary model, real-life simulation

Abstract

Understanding the process of disease transmission is essential for preventing and mitigating the spread of infectious disease, yet it is impossible to observe exact transmission events in the real world. There is a need to leverage new technologies to generate realistic datasets to help researchers study behavioral determinants of transmission and to design new and validate existing models of outbreak reconstruction and risk prediction. Motivated by this need, we have developed Operation Outbreak (OO), an app-based outbreak simulation platform for live simulation of an epidemic through a real social network (Colubri A, et al. 2020). OO transmits a virtual pathogen through participating smartphones and generates contact tracing data that reveals behavioral patterns of disease transmission. In this work, we demonstrate how to combine GAMA with OO to use the former as an entirely computational agent-based model (whereas in OO the agents are real individuals interacting in the physical world) that enables us to configure and “debug” OO simulations before carrying out large-scale deployments. Recently, our lab demonstrated the utility of OO-generated data in training an epidemiological model of disease transmission on college campuses (Specht I, et al. 2022). The next step in OO involves developing a genetic model to drive the “intra-host” evolution of synthetic pathogen genome sequences stored on the phones, enabling the generation of ground-truth phylogenetic trees capturing the entirety of host-to-host transmissions as well as the intra-host variability of the pathogen. This highly unique data from OO simulations will be useful to evaluate performance of transmission network reconstruction methods and to learn about the properties of epidemics. Existing tools allow to simulate contact and transmission networks and phylogenetic and sequence evolution, such as the FrAmework for Viral Transmission and Evolution Simulation (FAVITES) (Moshiri N, et al. 2019). However, a key difference in our approach is that the epidemic simulation in OO is driven by the real-life social network of the participants and therefore, by their (unpredictable) behaviors. We are following a multi-step approach focused on SARS-CoV-2, where the first step consists in comparing and tuning viral evolution models in FAVITES, prior to the second step of incorporating those models into GAMA’s COMOKIT (Gaudou B, et al. 2020) to run COVID-19 agent-based simulations in college campus scenarios matching our planned real-life deployments. We will customize COMOKIT to support dynamic genome entities that can be modified throughout the simulation to represent the emergence of novel variants due to random mutation. As the final step, the resulting ground truth models will be used to conduct a live OO simulation of the spread of a virtual virus on an entire college campus in the U.S., for which we will recruit a representative cohort including students, faculty, and staff. This result in contact data coupled with the complete phylogenetic tree of the virtual virus. This will represent the first genetic-epidemiological dataset comprising the full description of a simulated live outbreak, including real-world contact data and synthetic viral genomes.

Additional material

Project website: <https://operationoutbreak.org/>

References:

- Colubri A, Kembal M, Sani K, et al. Preventing Outbreaks through Interactive, Experiential Real-Life Simulations. *Cell*. 2020;182(6):1366-1371. doi:10.1016/j.cell.2020.08.042
- Specht I, Sani K, Loftness BC, et al. Analyzing the Impact of a Real-life Outbreak Simulator on Pandemic Mitigation: an Epidemiological Modeling Study. *MedRxiv* 2022. DOI:10.1101/2022.02.04.22270198.
- Moshiri N, Ragonnet-Cronin M, Wertheim JO, Mirarab S. FAVITES: simultaneous simulation of transmission networks, phylogenetic trees and sequences. *Bioinformatics* 2019; 35: 1852–61.
- Gaudou B, Huynh NQ, Philippon D, et al. COMOKIT: A Modeling Kit to Understand, Analyze, and Compare the Impacts of Mitigation Policies Against the COVID-19 Epidemic at the Scale of a City. *Front Public Health*. 2020;8:563247. Published 2020 Sep 24. doi:10.3389/fpubh.2020.563247.

MANA-Flo, a multi-agent model to raise awareness about the sustainable development of a territory prone to flooding by river overflow and urban runoff

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Our societies are facing a wide range of challenges related to environmental transition, including risk management in a context of global changes. Flooding is one of the most significant risks and different structural and non-structural strategies are available to manage flood risk. Classical structural strategies are based on “hard” protection actions, which generate several problems (feeling of safety behind dykes, degradation of habitats, landscapes, etc.). An alternative is to integrate Nature-based Solutions (NbS) into risk management strategies. NbS bring together actions to protect, manage and restore ecosystems in order to address societal challenges, ensuring human well-being and biodiversity conservation.

The objective of the MANA project (Modelling to increase the acceptability of NbS) is to design a model and a tool to raise awareness on flood risk management on the one hand, and on the implementation of NbS on the other hand. MANA uses an approach that couples a multi-agent model developed under GAMA (MANA-Flo) with a serious game (Sim-MANA). MANA-flow uses a double dynamics (alternatively): the flood simulation phase and the management phase. For the flood simulation, it uses a simple hydraulic models coupled with the consideration of inhabitants’ behavior (escape, protection of one’s property or car, etc.). Thus, it simulates the conjunction between human action and the propagation of the flood, with its consequences on the system (for example, the closure of roads). The model provide a simulation of different hazard scenarios (rain intensity and water from upstream). The management phase allows the user to interact with the simulation (interactive simulation) by implementing projects on the model, which then simulates a flood and evaluate the consequences of the selected projects on different indicators (safety, attractiveness and environment).

One of the original features of this work is the use of a 3D La Vita model and tangible interfaces. The territory reproduced by the model is a virtual city (la Vita) inspired by Vitrolles and La Ciotat. This choice allows the development of a tool that can be transposed from one territory to another. Interaction with the simulation is done through physical objects, by moving them on the La Vita model. In the game (Sim-MANA), players take on one of the following five roles: Municipal team, Technical services, Environmental union, Residents’ representative and Business representative. In each round (which represents one year each), players choose projects they wish to carry out from a panel of 19 projects divided into 3 choices or levels, under budget constraints. The selected projects are implemented in the simulation. A flood event is then simulated, with an intensity varying from a ten-year flood to a one hundred-year flood, and projected onto the La Vita model. A set of indicators is evaluated after the event to take into account the evolution of the situation (e.g. the projects implemented). The game is played over several rounds, allowing the players to develop their strategies.

Agent-based model for the analysis of urban overtourism in Santa Marta - Colombia

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Keywords

Overtourism, Tourist floating population, Population load, Urban destination, Tourist carrying capacity.

Abstract

This research has the objective of analyzing the events that are generated when urban capacities are exceeded, for which a conceptual and theoretical model of urban overtourism (MOV) was developed, in the practice, the classic models have been focused in an isolated analysis of urban context, tourist sector and floating population. Although, the MOV is an articulated theoretical model, but, in empirical terms there is no an applied articulated instrument from understand the complexity of the phenomena. However, the agent-based models (ABM) are useful for understanding the complex interactions between heterogeneous agents, and between these and the environment (Aguilera & Posada, 2018); in addition, the ABM have the ability to generate possible future scenarios and study the effects of economic policies (Hamill & Gilbert, 2016).

For this reason, the ABM went applied for understand the phenomena of the overtourism in Santa Marta – Colombia, through the software Gama. The general purpose went illustrate the behavior of the destination against different levels in the number of tourists who visit it, thus allowing to diagnose the moment when the phenomena of the overtourism manifests itself, and with it, the population load and the associated tourist load; in addition, evaluate the results of the application of strategies management of the phenomenon. The ABM have three entities: global environmental (world), spatial units and agents. The world is a rectangle that is delimiting the destination. We have two spatial units: the road network; and the polygons where the agents reside (MZ Hogar), recreate (MZ SIT) and spend the night (MZ Hospedaje). The agents are residents and tourists, they make decisions and interact between them and the other entities; the residents have a home (MZ Hogar) and they move between recreation sites (MZ SIT) and home, and the tourists move between recreation sites and hosting sites (See Figure 1).

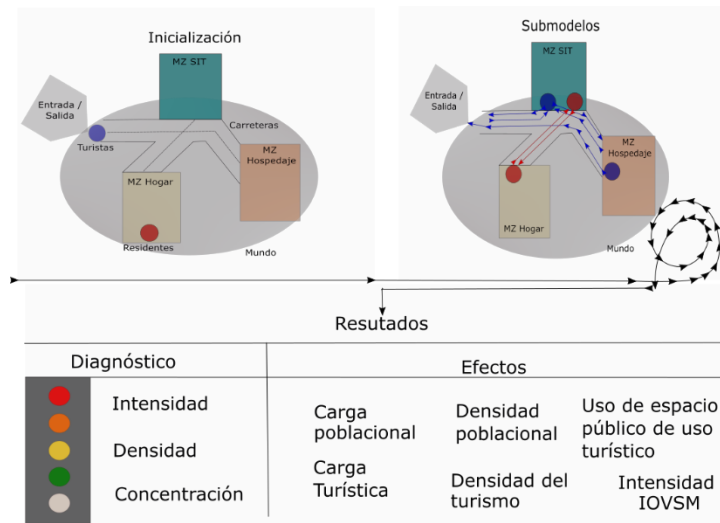
The ABM in Gama of overtourism has the added values: 1. the ABM has the ability to generate a diagnosis of the destination for identifying the condition of presence or absence of the phenomena, in this case, Santa Marta has high risk of overtourism, 2. an adjusted indicator of the intensity of tourism is formulated, since the overestimation of other indicators used in the literature was evidenced, in this case, Santa Marta has an annual intensity tourism up to 3.5%, that is, in a year 1000 residents cohabit with 35 tourists, 3. the ABM allowed us to observe temporal changes at a minimum scale (hours) and a maximum scales (year), likewise, it allows us to observe different spatial scales, from the minimum (MZ), up the maximum (destination); Santa Marta has peaks of increase in population loads in the tourist sites called: Rodadero, Centro Histórico, Minca and Taganga, 4. the ABM allows evaluating possible results of management strategies of the phenomena, making it possible to evaluate the impacts before its implementation, and 5. the ABM for overtourism allows the articulation of theories isolated by disciplinary barriers for the analysis of problems empirically.

Bibliography

- Aguilera, O. A., & Posada, C. M. (2018). ¿Qué son los sistemas basados en agentes? In *Introducción al modelado basado en agentes. Una aproximación desde NetLogo* (pp. 21–30). San Luis Potosí: El Colegio de San Luis.
- Hamill, L., & Gilbert, N. (2016). Why agent-based modelling is useful for economists. In *Agent-based modelling in economics* (pp. 1–9). Wiley.

Additional material

Figure 1. Summary of the process and results



Fuente: own elaboration

A multi-agent model of inhabitants' mobility in a French city and a study of its effects on air quality

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Keywords

Multi-agent modeling, machine learning, traffic simulation, Air quality

Abstract

Faced with the challenges of accelerating climate change, governments and authorities have an obligation to respond quickly to this threat by taking swift and intelligent action. Smart cities are becoming an important part of the solution by providing tools to model and conceptualize cities as well as to support decision-making and scenario testing.

We present a tool that simulates the French city, Rennes, and its inhabitants in order to study the effect of their mobility on air quality. Before building the model in GAMA, we generate a synthetic population based on a combination of the real population's census data as well as survey data from 2018 covering a representative sample of the citizens and containing details on their profiles as well as their mobility habits. A series of statistical methods and machine learning algorithms are developed to complement the survey data with the aggregated data. We then model the city's vehicle fleet using public data and statistical laws. Given the generated population and the vehicle fleet distribution, as well as GIS data from OpenStreetMaps and other regional datasets, the GAMA platform is used to model the city of Rennes and its suburbs at a microscopic scale.

The output files of this simulation contain the number of cars per street, their average speed, and their category according to fuel, segment, and European standard, all of which are necessary to calculate traffic emissions. The final step will be the generation of pollution maps showing the concentration of different pollutants per hour.

Simulating the function of a historic canal system

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Keywords

Hydrologic modeling, historic hydro-engineering, cellular automata

Abstract

The remains of canal-shaped landforms in Austria bear witness to historic construction work. So far, no clear evidence for their function could be found. One hypothesis assumes historic hydro-engineering as a response to dry climate conditions.

To investigate this hypothesis, the original path of the canal was reconstructed. First, cells that correspond to modern infrastructures (like buildings, bridges and roads) were erased from a 1m LiDAR DTM. Then the gaps in the perforated DTM were interpolated using Spline interpolation and a low-pass filter. Subsequently, the purged DTM was used as an input to a least cost path analysis that approximates the original canal path in those canal sections that were overprinted by modern infrastructure and agriculture. To test the functioning of the canal infrastructure, water flow in the reconstructed canal system was modelled by means of GAMA. The flow algorithm was implemented as cellular automaton that models lateral propagation between neighboring cells as a function of height differences of the water column. The implemented GAMA model supports single flow as well as multi-directional water flow.

Path and gradient of the reconstructed canal corresponds to the observed imprint and geometries measured in the field. The simulation shows that the canal fulfils its assumed function to direct river water to nearby agricultural fields. Nevertheless, the question remains open whether river water was diverted for the purpose of irrigation, to drive a watermill or to fulfill other functions.

IMPLEMENTATION OF A SIMULATION MODEL OF RISKS OF MENINGITIS EPIDEMICS IN THE SAHEL CONTEXT

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Meningitis is an inflammatory process that affects the membranes surrounding the brain and spinal cord. It is a contagious disease, transmitted by human contact through droplets of respiratory or pharyngeal secretions of infected people. Between 25,000 to 250,000 cases are observed each year in the meningitis belt which extends from Senegal to Ethiopia. Meningitis is generally associated with a case fatality rate of between 8% and 15% in treated patients and over 70% when the disease is untreated. It is a sensitive climatic disease manifested mainly in the heart of the dry season.

Before 2010, *Neisseria meningitidis* serogroup A (NmA) was the leading cause of meningitis epidemics, accounting for nearly 90% of disease outbreaks. The introduction of the vaccine called MenAfriVac® between 2010 and 2020 considerably reduced the number of cases of *Neisseria meningitidis* serogroup A but modified the bacteriological profile of meningitis which is marked by a predominance of other serogroups. In this logic, the introduction of a pentavalent conjugate vaccine (of serogroups A, C, W, X and Y) in the years to come should make it possible to reduce yet morbidity from meningitis and mortality from *Neisseria meningitidis*. Thus, the major challenge of an effective response plan to epidemic outbreaks is based on the implementation of a risk assessment model. Indeed, there are no simulation tools for meningitis risk assessment that can effectively predict the occurrence, magnitude, and pathogens that may cause outbreaks in the future.

MenAfriSim is a simulation model of epidemic risks related to bacterial meningitis. We know that high temperatures and high dust concentrations in the air are significant risk factors in increasing the number of cases during meningitis epidemics. Thus, the main hypothesis of this project is that a population subjected to a certain climatic and environmental condition becomes vulnerable with a high probability of infection. Given the demographic factors including the density of inhabitants in a city, the first cases of meningitis will appear. Social interactions as well as inter-urban mobility will contribute to amplifying the spread of the disease.

Thus, the epidemiological model integrates a climate-sensitive infection index into the classic scheme of the SIR model. This index takes as input temperature and dust concentration (PM10) data from Copernicus Atmosphere Monitoring Service (CAMS) model/satellite merged products. It is the latest global set of atmospheric composition re-analysis data compiled by ECMWF (European Center for Medium-Range Weather Forecasts). The spatial resolution of the CAMS re-analysis is a grid of approximately 80 km. Data is available as 3-hour scans and 48-hour forecasts, initialized daily from scans at 00 UTC.

The model is initially developed and tested in Senegal.

Improving the Decision Making Process in Urban Planning Through Agent-Based Models. Use Case: the University Cultural District (UCD), Zapopan, Mexico.

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Keywords

Agent-based Model, Urban Planning, Tangible User Interface

Abstract

Currently, most of the population is concentrated in urban areas. In Mexico, this phenomenon has been coupled with extreme urban sprawling which has generated an increase in commuting times, lack of services in the peripheries, the creation of gated communities and the surge of empty urban spaces within the city that add to the discontinuity of the territory. Therefore, vacant parcels inside the city have been seen as an opportunity to develop a new model of city which can redress the nuisances arisen in the previous developments. After analyzing the nature of the problems caused with the previous model of urban development, we identified they add into three main problems: 1) lack of social cohesion and segregation 2) dysfunctionality due to the lack of amenities and, 3) high impact on the environment and high consumption of land. Having this in mind, it was decided to create a model based on three axes that counteract the above mentioned issues: diversity, functionality and environmental sustainability. Each one of the axes was subdivided into variables and indicators to measure the magnitude of characteristics associated with each one of them. This way, the Diversity axis assesses diversity and balance of uses; the Functionality axis looks over density of population, provisioning of amenities and proximity of the population to them; and, the Sustainability axis evaluates the impact of the development in the natural cycle. This work proposes an Agent Based Model (ABM) to evaluate the impact of urban interventions in the case-study area. Such interventions are measured through the indicators above-mentioned which were selected based on its relevance to the topic as well as on the availability of data. The interventions simulated correspond to projects developed as part of a Master Plan created in 2014 for the urbanization of the entire district. With this model is intended to evaluate the suitability of the projects and their performance in today's standards. Agents of different classes are considered: people, streets, blocks, projects, intervention polygons, etc. The model generates as a result of the interaction between the agents, a series of indicators classified in three areas: functionality, environmental impact, and diversity. The model was implemented in a Tangible-User Interface (TUI), called City Scope, using the GAMA platform, and taking as a case study, the University Cultural District (UCD) in Zapopan, Mexico. Among the results obtained in the first phase it was observed that the district works as a metropolitan attraction node due to its important educational and cultural amenities. However, its density of population is exceptionally low and there is a void of urban transportation at the core of the district which results in a high use of private transportation and traffic congestion. Nevertheless, these phenomena were mitigated during the iteration with the proposed projects which proves the functionality of the tool and its importance in the assessment of future interventions. The implementation of this model has resulted in a tool that has brought together a multi-disciplinary group of actors involved in the planning process of the CCU such as, developers, researchers and decision makers. In the future, this tool could be extended to assess a wider variety of projects customized to the purposes needed in each specific case study.

Additional material

The figure 1 shows the result of the implementation of the model, using the GAMA platform. In addition, the figure 2 also shows the implementation in the CityScope table.

Github repository: <https://github.com/CityScienceLab-GDL/cityscope-ccu.git>

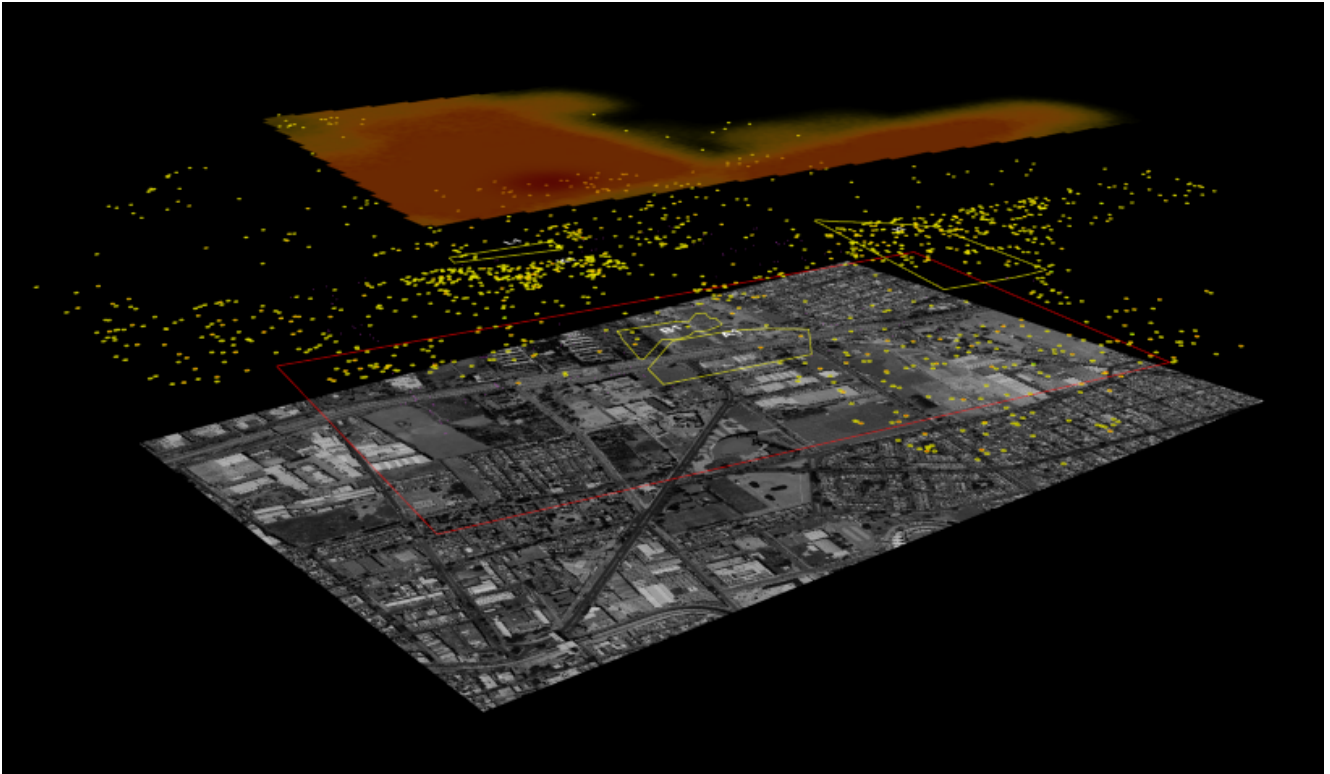


Figure 1: Model implementation in GAMA

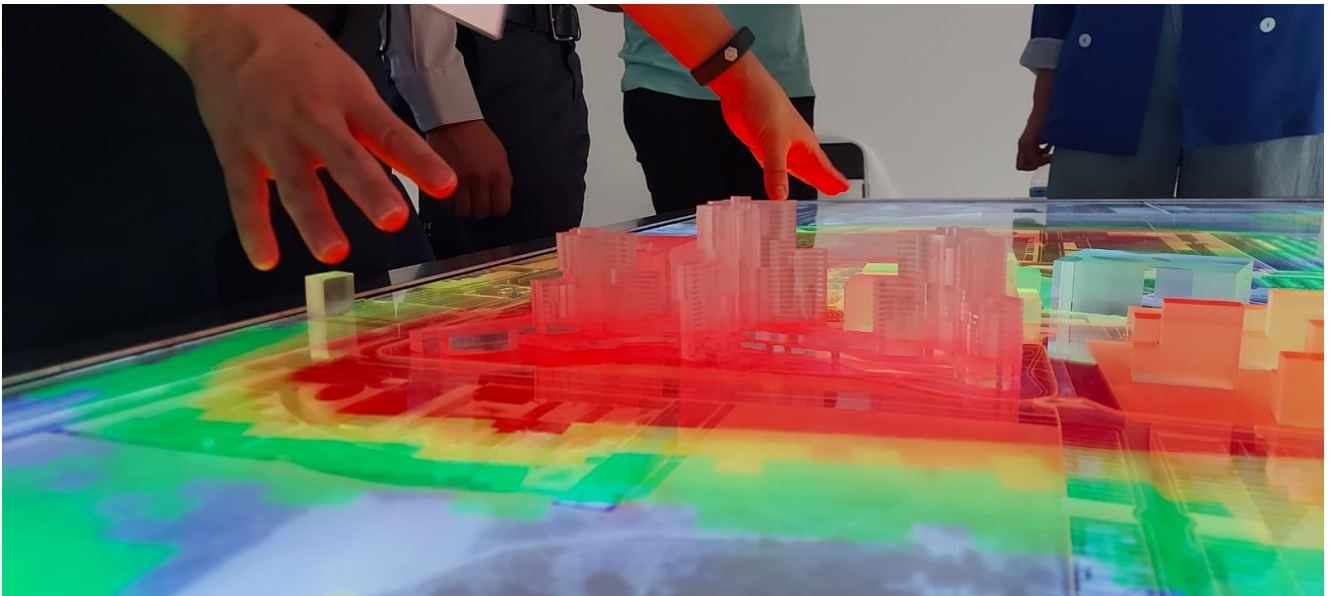


Figure 2: Implementation in the CityScope table

Simulating innovation diffusion using agent based modeling, argumentation and the theory of planned behavior

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Keywords

Agent-based simulation, Diffusion of innovation, Argumentation, Theory of planned behavior

Abstract

To answer water management problems due to drought in the south of France, the local institution has offered new communicating meters to farmers who use the Louts rivers to irrigate their crops. Those new meters are more accurate than the old ones and allow the farmers and the institution to know the water consumption in real time. The institution is interested in knowing the water consumption in real time because it is responsible for filling the river with the help of a dam. However the farmers of this region are not enthusiast to use those new meters mainly because they are suspicious about where the collected data are going. This case shows the interest in studying the innovation diffusion as it promotes a virtuous use of water resource.

Agent based modeling is one of the most popular paradigm for social simulations, there is already plenty of agent based model for innovation diffusion [4]. However in the existing models the agents representations of their opinions about the innovation is simplified, usually a float between -1 and 1. This kind of representation is great to study the dynamic of opinions but in the case of a model based on real data it doesn't provide information on the agent state of mind. Our model use the Theory of Planned Behaviour [1] as the cognition frame for agents. The theory is centered around the intention to adopt a behaviour or an innovation in our case. The intention is derived from attitude which is the agent opinion about the innovation, subjective social norm which is the agent impression about what its relatives think about the innovation and finally the perceived behavioural control that represents its ability to adopt the innovation (in terms of money, time, skill, ...).

The main contribution of our work is the way we compute attitude using argumentation theory. We manage to compute the attitude value using each agents knowledge modeled as an argument graph using the same approach as the one proposed by [3] and the semantics proposed by [2].

References

- [1] Icek Ajzen. The theory of planned behavior. *Organizational behavior and human decision processes*, 50(2):179–211, 1991.
- [2] Leila Amgoud, Jonathan Ben-Naim, Dragan Doder, and Srdjan Vesic. Acceptability Semantics for Weighted Argumentation Frameworks. In *Proceedings of the Twenty-Sixth International Joint Conference on Artificial Intelligence*, pages 56–62, Melbourne, Australia, August 2017. International Joint Conferences on Artificial Intelligence Organization.
- [3] Patrick Taillandier, Nicolas Salliou, and Rallou Thomopoulos. Introducing the Argumentation Framework Within Agent-Based Models to Better Simulate Agents' Cognition in Opinion Dynamics: Application to Vegetarian Diet Diffusion. *Journal of Artificial Societies and Social Simulation*, 24(2):6, 2021.
- [4] Haifeng Zhang and Yevgeniy Vorobeychik. Empirically grounded agent-based models of innovation diffusion: a critical review. *Artificial Intelligence Review*, pages 1–35, 2019.

Acknowledgements

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Autonomous shared micro-mobility: A swarm-based approach

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May 31, 2022

Abstract

Urban mobility is a complex system where the many layers interact in cyclic and often non-linear ways. Current trends toward micro-mobility, autonomy, and sharing [3, 2] indicate that the complexity of transportation systems is bound to increase in the coming years. Increased complexity makes traditional centralized planning each time more challenging, demanding new ways of coordinating fleets of vehicles. While autonomy is one of the drivers of increased complexity, it brings new opportunities regarding the interactions between vehicles and how these interactions will impact system-level behavior. Autonomy will provide vehicles with the ability to communicate with other vehicles, humans, and their supporting infrastructure and the intelligence to make decisions based on this communication, which can lead to new ways of collective behavior. In the field of swarm robotics, self-organizing bio-inspired processes have been shown to provide great adaptability, flexibility, and robustness [1]. In this work, we propose a vehicle rebalancing — one of the most challenging operations in shared vehicle fleets — that works in a decentralized manner. The proposed system emulates a foraging ant colony. In the proposed system vehicles leave a virtual pheromone trail guiding other vehicles toward high-demand areas. Developed in GAMA, this agent-based simulation studies the performance and limitations of such a system taking Kendall Square in Cambridge (USA) as a scenario.

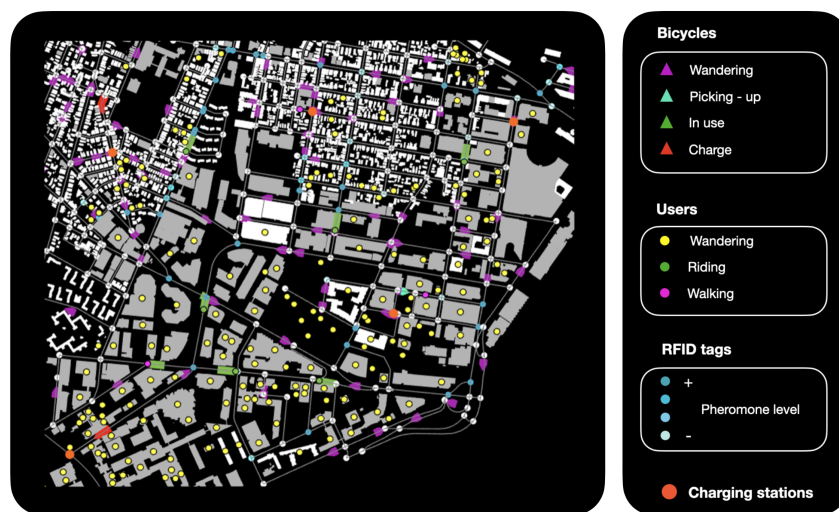


Figure 1: Visualization of the agent-based model in GAMA, showing an example of the different states of the agents at a given time.

References

- [1] Antonio Luca Alfeo, Eduardo Castelló Ferrer, Yago Lizarribar Carrillo, Arnaud Grignard, Luis Alonso Pastor, Dylan T Sleeper, Mario GCA Cimino, Bruno Lepri, Gigliola Vaglini, Kent Larson, et al. Urban swarms: A new approach for autonomous waste management. In *2019 International Conference on Robotics and Automation (ICRA)*, pages 4233–4240. IEEE, 2019.
- [2] Naroa Coretti Sánchez, Iñigo Martinez, Luis Alonso Pastor, and Kent Larson. Simulation study on the fleet performance of shared autonomous bicycles. *arXiv preprint arXiv:2106.09694*, 2021.
- [3] Naroa Coretti Sanchez, Luis Alonso Pastor, and Kent Larson. Autonomous bicycles: A new approach to bicycle-sharing systems. In *2020 IEEE 23rd International Conference on Intelligent Transportation Systems (ITSC)*, pages 1–6. IEEE, 2020.

Investigating factors influencing food choices in university catering through multi-agent simulation

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Keywords

Nutrition, Eating decisions, Social influences, Collective Catering, Multi-agent model

Abstract

Composing a meal from dishes offered in a self service buffet is a complex decision-making problem. Food choices are partly based on individual preferences but they are also influenced by contextual and interpersonal factors. The latter are often studied for an individual under the influence of his guests, but as soon as we consider that these influences can be reciprocal, as it is the case in real conditions, understanding and predicting the choices made amounts to studying the evolution of a complex system. In this context, the use of computer modeling methods could allow a better understanding of the complexity of the phenomenon at work. The objective of this study was to determine the influence of different factors on food choices in university restaurants by combining a computer simulation based on multi-agent modeling and *in situ* observations. A computer model allowing to simulate the choices of the guests of a university restaurant was designed and implemented using the GAMA platform. This model first integrates an estimation of the individual preferences of each agent for the dishes offered to him. These preferences are estimated from a consumption database (INCA3 study) by taking into account the age, gender, corpulence and physical activity of the simulated agents. During the simulation, these individual preferences can be modulated under the influence of the other individuals present, according to the relationships established between the agent and its other virtual guests (appreciation, familiarity, solidarity, dominance). The model also takes into account the importance attributed to sensory perceptions when the agent is close to a dish as well as the sensitivity of each agent to the time to wait before being able to serve himself. In parallel to the modelling work, observations were carried out in a university restaurant in the Paris region over 4 days and during lunch time. They consisted in recording the choices of starters, main courses and desserts made by the students. Information on age, gender, body size, physical activity, and sensitivity to interpersonal or physical influences was collected by means of a questionnaire. Simulations of choices were then carried out in the computer model designed by parameterizing it with the characteristics of the participants observed *in situ*; then, the comparison of the results of the choices of these simulated agents with those of the real participants made it possible to retain some sets of parameters of the model leading to the sets of choices closest to the reality. These parameter sets were interpreted and discussed as indicators of the determinants of choices in real life. Particular attention was paid to the analysis of the model parameters relating to interpersonal influences. Although the vast majority of respondents say that they are not influenced by others in their choice, the models with the best fitness give an important part to the choices of others in the decision. This study shows that an approach based on multi-agent simulation can reveal the influencing factors at work in natural food consumption situations.

Exploring an agent-based model to assess whether land and cattle repartition among households affects crop-livestock integration in West-Africa

Abstract submitted to the Gama Days

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Keywords

Spatially explicit simulation, Model exploration, Ecological network analysis, agropastoral systems

Abstract

Livestock raising and agriculture are increasingly decoupled in agrarian systems in south Sahelian Senegal, despite crop-livestock integration observed benefits : residues from crops provide forage to animals which manure can be used to maintain or increase fertility in cultivated parcels. Evolution of agricultural and livestock ranging practices may lead to changes in herd and cultivated land area repartition among households. The objective of this study was to assess the effect of livestock and land repartition among families on crop-livestock integration through the design of an agent-based model that simulated daytime cattle roaming and night parking. It accounted for vegetation and animal dynamics at the territory level and was ran for diverse state of repartition of animals and land. The model was fed a land occupation raster map and simulated nutrient flows through the length of a dry season. Herd behaviour was simulated with the help of a finite state machine running parameters from the literature. Simulations for diverse herd and surface randomly generated repartitions were run and the nutrients internal circulation rate (from the Ecological Network Analysis framework) was computed as a proxy for crop-livestock integration. Results seem to indicate no notable trend regarding the effect of surface repartition on integration and little to none for animal repartition among households. Additionally, useful insight were gathered on using simulation of Sahel agrosylvopastoral systems as a tool to explore the effect of cattle raising practices on coupled systems.

An end-user remote control interface for participatory simulation with GAMA

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Keywords

Agent-based simulation, Participatory simulation, Remote GUI

Abstract

In recent years, several agent-based simulation models have been produced to study complex systems in a wide range of domains. Three main stages are conducted: modelling, simulation and analysis of results, which represent the main focus of the majority of the proposed agent-based simulation tools [1]. Participatory modelling aims at using modelling in support of a decision-making process involving stakeholders in one or several stages of the modelling process [2]. Participatory simulation aims at allowing stakeholders to interact with a simulated model at runtime, often through a serious game [1].

However, most of the existing agent-based simulation tools do not support the involvement of the stakeholders in the modelling and simulation process. In fact, this makes them unsuitable for situations that require real-time interaction with the stakeholders. For instance, for building serious games as a support for decision-making processes. In such situations, it is necessary to simplify interactions and integrate relevant feedback among complex systems into the model. So, the stakeholders can make direct changes within the simulation process, as well as see the results of their changes almost instantly.

In light of the voids identified above, we aim to evolve GAMA to support participatory modelling. So, we developed a new generic tool, called GAMA Unity Client, that allows creating remote control interfaces based on several generic Graphical User Interface Elements like buttons, checkbox, Dialogbox, Selection Box, Text and so on.

GAMA Unity Client is developed as a generic scene that can be run on different devices without having to install GAMA (e.g. devices running under android) and hence allows stockholders to set up, from the model running in GAMA, a remote control interfaces and interact with the model during the simulation process. It consists of two parts: a GAMA plugin that implement a new agent's skill (called unity) and a Unity Client, as a Unity generic scene that can be installed in different devices, with different operating systems. So, it relies on the GAMA platform; which offers several multi-agent modelling and simulation tools and ii) Unity; which is a cross-platform game engine. The communication between the Unity Client and the GAMA Platform is made using the MQTT protocol.

Additional material

[1] Patrick Taillandier, Arnaud Grignard, Nicolas Marilleau, Damien Philippon, Nghi Quang Huynh, Benoit Gaudou, Alexis Drogoul: Participatory Modeling and Simulation with the GAMA Platform. *J. Artificial Societies and Social Simulation* 22(2) (2019)

[2] Barreteau, O., Bousquet, F., Etienne, M., Souchère, V. & d'Aquino, P. (2014). Companion modelling: A method of adaptive and participatory research. In *Companion Modelling*, (pp. 13–40). Berlin/Heidelberg: Springer.

Git: <https://github.com/GAMA-UNITY/GamaUnity>

A BDI model for water conflict management and cooperation among farmers during dry season using GAMA platform

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Keywords

Water management; BDI; Water regulation; Irrigation; Cooperative behavior

Abstract

Agent-based modelling is an important tool for understanding interactions between human and natural systems. Such models are alternatives to traditional modelling approaches, where human actions are usually considered as fixed boundary conditions. This work presents a spatially explicit agent-based model developed to represent and manage water use conflicts and cooperation among irrigators in the context of a Brazilian agricultural river basin during the dry season. The agent-based model uses a socio-hydrological approach and an agent-oriented software engineering methodology (Tropos [1]). In the model, there are two agent types to represent the dynamic of water management - the water user and the water regulator. A local regulatory authority agent and a farmer agent are instances of these agent types, illustrating the water use for irrigated crop production in the region. Agents are human-based decision-makers according to the Belief-Desire-Intention paradigm (BDI [4]). In the model, water users' main desire is to reach welfare, which in the case of the instantiated farmer agent may be achieved by selling their crop production and generating income. Heterogeneous behavior is taken into account by considering that each farmer agent acts according to one out of three cooperation profiles related to compliance with water use rules issued by the local regulatory agent, who in turn has the goal of providing sustainable water resources to users. The local water regulator defines their management strategies based on a set of rules to be issued according to the season and the water availability in the region. The GAMA Platform (v. 1.8.1) and its BDI plugin [2,3] are used to develop the agent-based model since the geographic location of water users plays a crucial role, with upstream and downstream users having different impacts on the model. The simulated scenarios may be evaluated using different metrics such as economic (overall basin income), ecologic (environmental flows), and social (income equity) variables.

Additional material

This work was carried out with the support of the Coordination for the Improvement of Higher Education Personnel - Brazil (CAPES) - CAPES-ANA-BDP Program process 88887.144867/2017-00.

[1] Bresciani, P., Perini, A., Giorgini, P., Giunchiglia, F., and Mylopoulos, J. (2004). Tropos: An Agent-Oriented Software Development Methodology. *Autonomous Agents and MultiAgent Systems*, 8(3):203–236.

[2] Taillandier, P., Gaudou, B., Grignard, A., Huynh, Q.-N., Marilleau, N., P. Caillou, P., Philippon, D., Drogoul, A. (2019). Building, composing and experimenting complex spatial models with the GAMA platform. *Geoinformatica*, (2019), 23 (2), pp. 299-322, DOI:10.1007/s10707-018-00339-6

[3] Taillandier, Patrick Bourgeois, Mathieu Caillou, Philippe Adam, Carole Gaudou, Benoit. (2017). A BDI Agent Architecture for the GAMA Modeling and Simulation Platform. 3-23. DOI: 10.1007/978-3-319-67477-3_1.

[4] Bratman, M. E. (1987). *Intention, Plans, and Practical Reason*. Harvard University Press, Cambridge, MA.

Getting Habits from (agent') User Experience. A contribution to simulating human-like everyday learning in ABMS.

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Keywords

Learning agents, human-like getting habits, human habitats (optimal living environments), artificial (built) environments, steering human behaviors by environment functionality

Abstract

(Obligatory.) A 500 words maximum abstract (28 lines). In any case, header (title, authors), keywords, abstract and additional material link must fit in 1 page. Please, do not change layout.

The base of the text is Times-Roman 10 points. The main title is in 17 bold points (28 points = 1cm). In sections, the title is in 12 bold points. There is not necessarily spacing between paragraphs and paragraphs are not offset.

Additional material

Recently, many contributions to joining ABMS and artificial intelligence were made (including Gama ad-ons). Although, the topic seems to be open (GamaDays2021), and knowledge gaps even fundamental. In evolutionary game theory (EGT) rudimentary memory was implemented: every player remembers previous interactions with others - what produces a bit different reactivities to every known player respectively. Our model of behavioral reinforcement (Skinner, Pavlov) continues this tradition: positive UX reinforces steering modules (in every agent separately) to repeat such experience. The difference (to EGT) is in (1) reward definition and (2) learning definition. Theoretical problem is that mathematical formalization of reward includes arbitral evaluation of fitness. Repetitive "wins" always cumulate "a winning". That might be considered a logical mistake, because real-world evaluation of fitness is (and has to be) after the player' mutations/changes. In our model there is not a reward. There is agents' change, with no evaluation after every step, every single change. This solution is useful for long-term, multi-interaction simulation, where fitness is an emergent, not a plan. Evolution has no aim. This basic phenomena was modeled quite easily, due to the current ABMS platforms (e.g. Gama). Additionally, ABMS is extremely helpful in simulation of multi-player co-evolution. In pure Darwinian model species evolves in a stable environment. In ABMS we can model parallel agents' changing. That means, ABMS is a ready-for use tool to explore real-live, biological phenomena like reciprocal-learning, steering aspects of physical objects.

Therefore, as architects, we ask a question: Can we automatically measure the quality of architectural design? Or, more generally, why built environment' optimization is still more of an art domain, than engineering one? And, during architectural competitions - can we clearly define all the design' quality parameters - and pick the winner by those parameters fulfilling and summarizing the score? Of course, not.

However, relying on medical proven standards, we focus on the cause-effect link between the suitable design of the environment and the inhabitant's health: the physical inactivity. Statistically, one of the deadliest problems of modern times, recently strengthened by anti-COVID-19's restrictions. The main physical inactivity preventive recommendation available both for older and younger people is recreational walking, at least 30 minutes per day to maintain health. Based on this value, we create a prototype agent-based model, that simulates and measures residents' time of recreational walking, where every inhabitant bases its walking's decisions on its unique/individual memory. In our GAMA model, simplified positive behavioral enhancement is the main rule of increasing motivation for walking. As a result (or emergent), we can observe the process of individual, spontaneous learning of new habits, which changes the amount of time spent on recreational walking, depending on the individual place of living.

This GAMA model can be applied to any location or landscape-urban design, to simulate its recreational walking potential (walkability) and to (more objectively) estimate the health impact of proposed design concepts and solutions. We believe using this tool might help architects and planners improve the recreational infrastructure in our cities.

Agent-based simulations and reinforcement learning for policy design to support innovation adoption

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Keywords

Agent-bases simulation, Reinforcement learning, Policy design, Innovation diffusion, Theory of planned behavior

Abstract

If some innovations (technological, practical, etc.) can be positive for the society, individuals can be reluctant, for a variety of possible reasons, to adopt them even when it can benefit them: misinformation, distrust of the hidden agenda of the institutions promoting it, lack of skills to use it, etc. In this situation the social planner may make use of different policies (information, financial aid, training,...) in order to overcome these barriers hindering the widespread adoption of the innovation. However, designing such innovation adoption policies is a very challenging task because of the difficulty to quantify and predict the effect of policies on the behaviors of non-adopters. Moreover, the implementation of a policy incurs an important cost on the restricted budget of a social planner.

Against this background, we propose to study the problem of designing innovation diffusion policies using agent-based simulations and reinforcement learning. One of the difficulties is however to define credible behaviors for the agents whereas keeping the computational cost of simulations affordable. In particular, in innovation diffusion, we need to model the human decision-making key-factors deciding on innovation adoption. We tackle this problem by building an agent-based model of the innovation diffusion based on the theory of planned behavior to describe the adoption of a new behavior. Another difficulty is that the social planner can not efficiently explore by trial-error the policy search space, given it is exponential. So we propose a model of social planner that uses reinforcement learning by interacting with the simulator to optimize the policies efficiently. Our approach allows to produce AI-designed policies for innovation diffusion.

In order to illustrate our approach, we propose an application of it to the question of the use of digital technologies in agriculture and more particularly to the adoption of communicating water meters by farmers in the Louts region (South-West of France). Indeed, in this area, farmers today mainly use mechanical meters which do not estimate water consumption correctly because of their low accuracy. If this is an advantage for farmers, this over-consumption is an important issue in this region where the water level of the rivers tends to decrease every year due to climate change. The institution in charge of managing water distribution in this area wants to install new communicating meters, which are more accurate and allow for real-time monitoring of each farmer's consumption. However, the institution is having difficulty convincing farmers to install this device because they perceive it negatively. Thus, the institution is now questioning the policy to be implemented in order to encourage the adoption of new meters.